유전 알고리즘에 의한 브러시리스 DC모터의 속도 제어용 혼합 H_2/H_∞ PID제어기 설계

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Design of a Mixed H_2/H_∞ PID Controller for Speed Control of Brushless DC Motor by Genetic Algorithm

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Abstract : A mixed method between H_2 and H_∞ control are widely applied to systems which has parameter perturbation and uncertain model to obtain an optimal robust controller. Brushless Direct Current (BLDC) motors are widely used for high performance control applications. Conventional PID controller only provides satisfactory performance for set-point regulation. However, with the presence of nonlinearities, uncertainties and perturbations in the system, conventional PID is not sufficient to achieve an optimal robust controller. This paper presents an approach to ease designing a Mixed H_2/H_∞ PID controller for controlling speed of Brushless DC motors and the genetic algorithm is used to solve the optimized problems. Numerical results are shown to prove that the performance in the proposed controller is better than that in the optimal PID controller using LQR approach.

Key words : PID control, robust control, genetic algorithm, BLDC motor.

1. INTRODUCTION

There have been a lot of approaches to search the parameters of optimal PID controllers to control of BLDC motors, including using iterative learning control, using LQR approach and H_∞. However, most of them only satisfy one of two criterions: optimal performance or robust performance.

Mixed H_2/H_∞ control designs have received a great deal of attention from the viewpoint of theoretical design. A mixed H_2/H_∞ PID is to find an internally stabilizing PID controller that minimizes an H_2 performance index using Genetic Algorithm (GA) subject to an inequality constraint on the H_∞ [3].

In this paper, the mixed H_2/H_∞ method is used to achieve an optimal robust PID controller which is applied to control speed of BLDC motor.

2. A MIXED H_2/H_∞ CONTROL PROBLEM DESCRIPTION

Consider the PID control system in Fig. 1. The plant $\Delta P(s)$ is assumed to be stable but uncertain, and bounded according to

$$|\Delta P(j\omega)| < |\xi(j\omega)|, \quad \forall \omega \in [0, \infty] \qquad (1)$$

where the function $\xi(s)$ is stable and known.

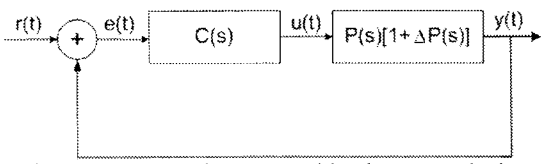

Fig. 1 PID control system with plant perturbation

The robust stability result reveals that if a controller $C(s)$ is chosen so that the nominal closed

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loop system in Fig. 1 is asymptotically stable, and the following inequality holds,

$$\left\| \frac{P(s)C(s)\xi(s)}{1+P(s)C(s)} \right\|_{\infty} \leq 1 \qquad (2)$$

then the closed loop system in Fig. 1 is also asymptotically stable under plant perturbation $\Delta P(s)$ in (2).

However, the control system designing with only robustness stability is not good enough. Optimal tracking performance is also appealing in many practical control engineering applications. Therefore, the mixed H_2/H_∞ control problem is formulated [3].

The value of H_2 performance, $J=\min\int_0^\infty e^2(t)$ can be found from [2] and it must be of the following form:

$$J_m = \min_{k_p,k_i,k_d} J_m(k_p,k_i,k_d) \qquad (3)$$

From the above analysis, our mixed H_2/H_∞ design problem becomes how to solve the minimization problem (3) under the inequality constraint (2).

3. NUMERICAL RESULTS

The transfer function of BLDC motor is [1].

$$P(s) = \frac{275577.36}{s^2+417.7s+43567.5} \qquad (4)$$

The plant perturbation is bounded as follows:

$$|\Delta P(s)| \leq \left| \frac{0.1}{s^2+0.1s+10} \right| \qquad (5)$$

The GA begins by randomly generating a population of 200 chromosomes. After 25 generations, proper PID controller parameters are obtained, and the corresponding PID control parameters are k_p=180.1755, k_i=4.6997, k_d=0.0353.

The speed response with plant uncertainty $\Delta P(s)$ is shown in Fig. 2. Table 1 lists the performance of the two different PIDs.

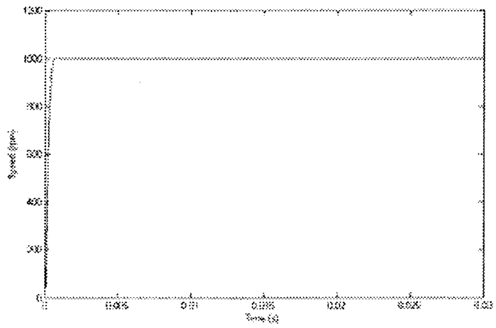

Fig. 2 Speed response of the mixed H_2/H_∞ PID with plant uncertainty

Table 1 Simulated performances of different PIDs

	PID [3]	Our PID
Rising time (ms)	0.55	0.45
Settling time (ms)	1.53	1.2
Overshoot (%)	0.15	0.09

4. CONCLUSIONS

In this paper, a mixed H_2/H_∞ PID has been applied and investigated to control speed of BLDC motor. Performance of the optimal robust PID is analyzed and compared with the optimal PID using LQR approach [1] for speed tracking. An uncertain model has been also considered to show the robustness of the PID controller. From the simulation results, it shows that a mixed H_2/H_∞ PID has better performance rather than the optimal PID using LQR approach [1].

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